Meteorological conditions associated with the rains.

Whatever may be the ultimate cause or causes of long-continued rains over the Plains States—particularly over Kansas and Nebraska—the immediate visible cause, referring to surface conditions only, is the immediate pressure distribution. This may be roughly characterized as a development of lows over the Middle Plateau region generally west of the Continental Divide, and a movement of such lows thence southeastward to the Texas Panhandle, thence northeastward to the Lake region with their paths converging over northwestern Missouri or northeastern Kansas. If the Lake region is occupied by areas of high pressure, which in the spring of the year often appear to exert a retarding influence on lows advancing from the southwest, the conditions for heavy and often continuous rains in the Missouri Valley are ideal. The great flood of May, 1903, when the rainfall for the month was greater than for the corresponding month of 1915, was due to the meanderings of a single low during the 10 days from May 21 to May 31. (See MONTHLY WEATHER REVIEW, May, 1903, Charts XI–XXII.)

The heavy rains of May, 1892, when the average for eastern Kansas was 8.72 inches as against 8.59 inches for May, 1915, are clearly traceable to the fact that five lows crossed eastern Kansas in that month. (See MONTHLY WEATHER REVIEW, May, 1892, Chart I.)

In May of the current year two lows, moving as shown on Chart IA of this issue of the REVIEW, were the visible cause of the heavy rains of the last ten days of May. On Chart IA have been also plotted the tracks of the two lows in June, and also (in red) the tracks of the highs that were associated with them, thus assembling on one chart the paths of the highs and lows chiefly concerned with the rainstorms. The general principles illustrated by the movements shown on Chart IA are familiar to forecasters and others, and have been stated in the beginning of this note. In connection with the May lows (17th and 25th), it will be seen that both of them failed to reach the Lake regions, the first one dissipated over Iowa and the second travelled far to the south, while No. III (June 11) moved quite rapidly northeastward; it gave but a short period of rain. The low of June 16, No. IV, also moved with considerable speed, apparently because its advance was not obstructed by a high. One of the highs charted apparently came from the region of Hudson Bay. It is known by experience that highs from that or even other regions of the north or northwest in the late spring or early summer often lodge over the Great Lakes and sometimes exert a strong retarding influence upon the movement of lows that may threaten to advance from the west or southwest.

In the last 29 years there have been three occasions in the month of May when the atmospheric conditions tended toward heavy and continued precipitation in the middle Missouri Valley, or about one year in ten. The same rule holds for June, but not for April or July.

Forecasting of floods.

In general, the floods enumerated in the foregoing were successfully forecast and a very material public service was thus rendered, especially in the densely populated suburbs of Kansas City along the river bottoms; also in the rich and prosperous farming communities along the Missouri River. The forecasts for the Kansas City district were made by P. Connor, of the Kansas City Station; those for the Missouri, east of Kansas City, by Montrose W. Hayes, of the St. Louis station.

Hydrographs for typical points on several principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.

LOSS BY FLOODS IN KANSAS RIVER AND TRIBUTARIES, JUNE, 1915.

By P. CONNOR, Local Forecaster.

[Local office, Weather Bureau, Kansas City, Kans.]

The northern half of Kansas suffered very heavy losses during June, due to the occurrence of severe local storms with exasperating frequency, which were attended by torrential rains, causing the smaller streams to rise with extraordinary suddenness, overflowing contiguous land, carrying away bridges, and later producing floods in the larger rivers.

Aside from the small streams which immediately responded to the local downpours, the first river to overflow its banks was the Solomon, which rose from 2.6 feet on the 3d to 32.3 feet in early morning of the 6th at Beloit, Kans., breaking the high water record by 1.1 feet. The rainfall which produced this flood fell in places remote from reporting stations, so that the rapidly rising river at Beloit was the first intimation. Warnings were promptly telegraphed to Minneapolis, Kans., and Solomon City on the 5th, and the slow movement of the crest in that river afforded time for protection of property. The river subsided to normal by the 10th.

The territory overflowed in Mitchell County was estimated at from 50 to 60 square miles with an added 20 miles due to overflow of creeks, approximately 48,000 acres in all, with damage close to one million dollars. From Mitchell County to Solomon City the damage has been estimated at $350,000.

A recurrence of local storms on the 17th, giving 5.78 inches of rain at Beloit from 8 a. m. to 5 p. m., caused a rise in the river at that place from 4.3 feet at 7 a. m. of the 17th to 23.4 feet at 7 a. m. of the 18th and to 32.4 feet, or 1.2 feet above high water mark, at 6 p. m. on the 19th, remaining out of its banks until afternoon of the 22d.

Warnings were telegraphed Beloit, Delphos, Minneapolis, Bennington, and Solomon City on the 17th advising of a second overflow of the valley. The same area was inundated by the second flood, but there was little to prey upon. It only made the damage more complete and delayed reclamation and farm operations.

Rains from 4½ to 6 and 8 inches on the 17th and 19th at and above Concordia caused the greatest flood known in the Republican Valley from Superior, Nebr., to Junction City, Kans., where the Republican joins the Smoky Hill to form the Kansas River. Warnings of this flood were telegraphed on the 17th to towns from Junction City to Concordia, and again on the 20th Clay Center and Junction City were advised that a pronounced flood was imminent.

The area inundated was 2 to 6 miles wide from Superior to Junction City. At Clay Center the maximum stage was 26.2 feet at 11 a. m. 21st, the highest previous water being 24.8 feet in 1903. There was no gage at Concordia, the river having separated itself from the city in 1903 by at least a mile, but the observer, Mr. John W. Byram, writes: "The crest of the flood passed in night of the 20th. The district under water was the richest and most fertile in this section of the country, consisting of vast fields of

rapidly ripening wheat, growing corn and alfalfa, all of which were practically destroyed. The swift running waters cut new channels, washed the surface of the land away in places, and covered thousands of acres with a heavy deposit of sand."

The damage to agricultural interests in this county, growing crops, land and improvements considered, will approximate $1,500,000. Many small bridges were badly damaged. The Missouri Pacific Railroad was damaged about $50,000. The Burlington and Union Pacific had not succeeded in restoring communication with Concordia July 3. No lives lost in this county, but boats were constantly employed from 2 a. m. to 6 p. m., Sunday, 20th, rescuing persons living in the flooded area.

Below Cloud County the damage was about $1,500,000. The river cut new channels in several places. At Clay Center it broke through the dike and cut a new channel through a soft, spongy bottom which, if permanent, would necessitate a new bridge at a cost of $60,000 and would render valueless a concrete dam that cost about $50,000. But it is believed that a new dike will be built, compelling the river to return to its old channel, a more economical proposition with a more enduring prospect than attempting to bridge a river which will inevitably make new channels with each succeeding flood.

At Junction City the water was about 4 feet in depth over the railroad tracks. The flood carried out two Government bridges and one county bridge, and twisted the electric bridge several degrees out of alinement, the damages to bridges amounting to $40,000.

The Big Blue at Blue Rapids rose from 8.7 feet on the 17th to 26.5 feet on the morning of the 18th, 5.5 feet above flood stage, causing overflow and damaging crops in the immediate bottoms from Blue Rapids to Manhattan. There was no loss of stock or bridges. The damage in the entire valley did not much exceed $500,000.

From Solomon City to Topeka (almost equally divided between the Smoky Hill and Kansas Rivers) only slight overflow occurred (except locally at Junction City), with a consequent loss of about 15 per cent of the growing crops, amounting to about $350,000.

Advisory warnings were frequently sent to the river observers at Abilene and Wamego and to the corn and wheat observers at Manhattan. The postmasters at Solomon City and Junction have stated that the telegrams from this office were conspicuously posted, were very valuable, and greatly appreciated. The river observer at Clay Center writes that the information telegraphed from this office enabled the people to take measures to protect their property and stock.

The damage at Topeka was slight.

East of Topeka a series of freshets occurred between May 18 and July 3. From May 18 to 28, inclusive, more rain fell within a radius of 60 to 70 miles of Kansas City than during the entire month of May, 1903, the year of the great flood. Heavy rains on May 26, 27, and 28 caused all the smaller streams to overflow, doing much damage to crops on adjacent land, carrying away bridges, etc. The Kansas River bottoms were overflowed in many places for a distance of 30 miles west of Kansas City. Local downpours formed ponds and lakes in depressions, and much damage resulted to corn, potato, and alfalfa crops. In fact, a considerable portion of the bottoms was not free from water from the latter part of May to the first week in July, and even then several weeks without rain were required to dry up the numerous ponds.

The damage to potato, alfalfa, corn, and trucking crops in the Kansas Valley east of Topeka is estimated between $750,000 and $1,000,000.

Although the heavy rains occurred simultaneously over the northern tributaries, the flood waters did not synchronize in the main artery. This was owing partly to the meandering courses of the streams, some of them bordered by shrubbery which, with overflowed wheat fields, retarded movement and smoothed out the crests. In addition, the maximum effect of the nearest tributary passed in the Kansas River before the next arrived, so that the Kansas Valley was spared a great flood.

The floods of 1903 and 1908 left an undesirable legacy to the farmers along the Kansas River between Topeka and Kansas City. The swift-moving currents in those floods, instead of following the channel, took a more or less direct course, cutting off curves, and in so doing, scoured out slight depressions of considerable width. Now, it happens that before the water is as high as the bank crests it enters the bottoms on the west approach of each curve, and the consequence is that water covers a much larger area and remains on the bottoms much longer than formerly. This is particularly noticeable at Linwood, Eudora, Loring, Lenape, and Holiday.

Recapitulation of flood damages on the Kansas River, June, 1915.

Solomon Valley	$1,350,000
Republican Valley	3,000,000
Big Blue Valley	500,000
Smoky Hill and western portion of Kansas	350,000
Kansas, east of Topeka	750,000
Total	5,950,000

Estimate of highway engineers of damage to bridges, large and small, in the various counties in the Kansas River watershed, furnished Governor Capper of Kansas:

Damages to bridges in the Kansas River watershed.

Republic	$100,000	Shawnee	$30,000
Cloud	150,000	Jefferson	75,000
Clay	150,000	Douglas	20,000
Geary	125,000	Leavenworth	50,000
Riley	50,000	Marshall	75,000
Wabaunsee	20,000	Ottawa	10,000
Washington	25,000		
Mitchell	25,000	Total	1,005,000
Pottawatomie	100,000		

The damage along the Missouri, Kansas City to Lexington, to crops was about $1,500,000. The damage to bridges and highways in the counties bordering the Missouri between St. Joseph and Lexington was $161,500.

MEAN LAKE LEVELS DURING JUNE, 1915.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., July 6, 1915.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during June, 1915:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York	601.95	579.78	571.86	245.12
Above or below—				
Mean stage of May, 1915	+0.30	+0.14	+0.17	−0.03
Mean stage of June, 1914	−0.51	−0.82	−1.17	−1.79
Average stage for June, last 10 years	−0.32	−1.20	−1.11	−1.92
Highest recorded June stage	−1.48	−3.82	−2.66	−3.51
Lowest recorded June stage	+0.71	−0.12	+0.29	+0.23
Probable change during July, 1915	+0.2	+0.1	−0.1	−0.1